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MADEP Northeast Regional Office
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Subject: Frequency Analysis Using Refined Dispersion Modeling - Crow Lane Landfill Flare
Crow Lane Landfill, Newburyport, Massachusetts
IRASS Project Number 101206

Dear Mr. Carrigan:

Massachusetts Department of Environmental Protection (MADEP) retained ENSR to evaluate the dispersion of emissions from the flare at the Crow Lane Landfill in Newburyport, Massachusetts. Emissions of chemical constituents from the flare were estimated based on field measurements conducted in March 2006. The purpose of dispersion modeling was to estimate the potential concentration levels of these constituents at specific locations selected by MADEP, representing nearby public facilities (such as schools and hospitals) as well as residential areas.

In a report dated July 10, 2006, ENSR summarized the refined modeling conducted using the AERMOD model with two years (2004 and 2005) of meteorological data from nearby Portsmouth/Pease Airport, NH. The purpose of the refined modeling was to provide upper-limit estimates of concentrations at the specified locations. Based on this assessment MADEP has asked ENSR to evaluate the frequency of modeled concentrations of three substances, sulfur dioxide (SO_2), carbonyl sulfide, and hydrogen sulfide, relative to their MADEP short-term threshold. ENSR has conducted a frequency analysis on the results from the refined dispersion modeling to determine the number of hours over the two year period when modeled concentrations exceeded certain thresholds for two of the refined modeling scenarios (Cases 1A and 2B).

This report discusses the methodology used and the results of the frequency analysis.

Methodology

ENSR conducted the frequency analysis for two of the refined modeled scenarios discussed in the July 10, 2006 report, Cases 1A and 2B. For Case 1A, the flow rate of landfill gas to the flare was measured at 23 cfm, without the use of supplemental propane. For Case 2B, the ideal flow rate of the landfill gas to the flare is 130 cfm and propane is added to keep the flare burning at a higher efficiency. Model input parameters for these cases are summarized in Table 1.

Table 1 Model Input Parameters

Parameter	units	Case 1A	Case 2B
		Current - No Propane	Ideal with Propane
Flare Stack Height	ft	20	20
Landfill Gas Flow	cfm	23	130
Total Heat Release Rate	Btu/hr	246100	2782000
Flare Stack Height	m	6.10	6.10
Model Assumptions for Flares			
Exit Temperature	K	1273	1273
Exit Velocity	m/s	20	20
Exit Diameter	m	0.087	0.256
Receptor Height above Ground	ft	5 (breathing height)	5 (breathing height)
Receptor Height above Ground	m	1.524	1.524

As described in the July 10, 2006 report, ENSR used the AERMOD dispersion model with two years of hourly meteorological data from the Portsmouth/Pease Airport. The same model, meteorological data, and receptor locations were used in this analysis. Based on the July 10 modeling results, MADEP identified three compounds of concern for the 1-hour averaging period: sulfur dioxide (SO_2), carbonyl sulfide, and hydrogen sulfide.

The emission rates of these compounds of concern are provided in Table 2 for Case 1A and 2B. Additionally, for each Case, several operating scenarios were assumed:

- The flare is assumed to destroy reduced sulfur compounds (and VOC) at 80% efficiency. This is highly conservative because, when operating properly, the flare is designed to oxidize VOCs and reduced sulfur compounds at a much higher efficiency, e.g., 90% or better.
- A second case where the flare is assumed to destroy reduced sulfur compounds at 90% efficiency. This represents the concentrations when the flare is operating properly.
- For sulfur dioxide it is assumed that 100% of sulfur in the landfill gas is converted to SO_2. This assumption effectively "double counts" 20% of the sulfur which, as noted above we assume that the flare is operating at 80-90% efficiency.

In the calculations of all emissions, concentrations of the compounds of concern were based on the measurements of respective compounds in the landfill gas as measured on March 9, 2006.

Table 2 Flare Emissions for Cases 1A and 2B

Compound	Case 1A (g/s)			Case 2B (g/s)		
	Flow to Flare	80% Efficiency	90% Efficiency	Flow to Flare	80% Efficiency	90% Efficiency
Carbonyl Sulfide	9.323E-02	1.86E-02	9.32E-03	5.27E-01	1.05E-01	5.27E-02
Hydrogen Sulfide	6.189E-01	1.24E-01	6.19E-02	3.498	7.00E-01	3.50E-01
Sulfur Dioxide(1)	1.387	1.387		7.842	7.842	
(1) Sulfur Dioxide emissions assume 100% conversion.						

ENSR conducted the modeling for each case and compound with the AERMOD dispersion model. AERMOD has an option where the user may select a threshold value such that if the modeled concentration is equal to or greater than the threshold, the date, concentration, and receptor location is written out to a file. For this assessment MADEP selected a threshold value of 10 $\mu g/m^3$ for carbonyl sulfide and hydrogen sulfide, and a threshold value of 660 $\mu g/m^3$ for SO_2.

The threshold output files were imported into Excel and sorted by receptor location. The number of times the concentration exceeded the threshold at each modeled receptor was divided by the total number of hours modeled over the two years to calculate the percentage of hours with modeled 1-hour average concentrations over the threshold. Due to missing meteorological data and calm hours during which the model does not calculate concentrations (about 10% of the time), the total number of hours modeled over the two years is 15,767.

Results

Tables 3 and 4 show the results for Case 1A and Case 2B, respectively. For Case 1A, there were no hourly modeled concentrations of SO_2 or Carbonyl Sulfide greater than their respective threshold values. Hydrogen Sulfide concentrations are greater than the threshold no more than 1.2% of the time if the flare is assumed to be 80% efficient and no more than 0.6% of the time if the flare is 90% efficient. For Case 2B, the hourly modeled concentrations of SO_2 are greater than the threshold only 0.7% of the time. Hydrogen Sulfide concentrations are greater than the threshold no more than 5.7% of the time if the flare is 80% efficient and no more than 2.7% of the time if the flare is 90% efficient. Carbonyl Sulfide concentrations are greater than the threshold no more than 0.6% of the time if the flare is 80% efficient and there are no hourly concentrations above the threshold if the flare is 90% efficient.

Sincerely,

David Heinold, CCM
Senior Air Quality Meteorologist

Mary Kaplan
Air Quality Modeling Specialist

Table 3 Case 1A Results

Location	UTM East (m)	UTM North (m)	Percent of Hours Modeled Exceeding Threshold				
			SO_2	Hydrogen Sulfide (80% Efficiency))	Carbonyl Sulfide (80% Efficiency)	Hydrogen Sulfide (90% Efficiency)	Carbonyl Sulfide (90% Efficiency)
Merrimac Place Assisted Living	343787	4742150	No Modeled Concentrations Greater than 660 $\mu g/m^3$	0.26	No Modeled Concentrations Greater than 10 $\mu g/m^3$	0.10	No Modeled Concentrations Greater than 10 $\mu g/m^3$
K-Mart @ Low Street	344220	4742260		0.28		0.02	
Doe Run Dr. @ turnaround	344422	4740960		0.18		0.00	
Wildwood @ Quail Run Hollow	344582	4741250		0.51		0.13	
Low Street @ Murphy Street	344615	4742120		0.55		0.11	
3 Doe Run Drive	344649	4740910		0.20		0.00	
3 Charmanski Drive (Monitor)	344687	4741380		1.15		0.57	
Senior Center	344897	4741870		1.15		0.63	
Belleville School	344981	4742360		0.26		0.01	
Hale St. @ Squires Glen Drive	345010	4740980		0.43		0.00	
Day Care Center	345015	4741460		1.19		0.56	
Bresnahan School	345220	4742380		0.33		0.05	
Acute Care/Rehab Facility	345275	4741130		0.74		0.37	
Anna Jacques Hospital	345376	4741750		0.62		0.39	
Currier School	345464	4742360		0.32		0.11	
Knox Middle School	345590	4741100		0.56		0.29	
Newburyport High School	345725	4741550		0.60		0.27	
Elderly Housing off Low Street	346128	4741030		0.27		0.03	
Davenport School	346128	4741620		0.38		0.10	

Table 4 Case 2B Results

Location	UTM East (m)	UTM North (m)	Percent of Hours Modeled Exceeding Threshold				
			SO_2	Hydrogen Sulfide (80% Efficiency))	Carbonyl Sulfide (80% Efficiency)	Hydrogen Sulfide (90% Efficiency)	Carbonyl Sulfide (90% Efficiency)
Merrimac Place Assisted Living	343787	4742150	0.13	1.00	0.13	0.36	No Modeled Concentrations Greater than 10 $\mu g/m^3$
K-Mart @ Low Street	344220	4742260	0.00	1.26	0.13	0.11	
Doe Run Dr. @ turnaround	344422	4740960	0.00	0.23	0.00	0.00	
Wildwood @ Quail Run Hollow	344582	4741250	0.18	2.18	0.13	0.78	
Low Street @ Murphy Street	344615	4742120	0.00	2.02	0.00	0.34	
3 Doe Run Drive	344649	4740910	0.00	0.48	0.00	0.05	
3 Charmanski Drive (Monitor)	344687	4741380	0.66	5.63	0.55	2.66	
Senior Center	344897	4741870	0.55	4.71	0.46	2.37	
Belleville School	344981	4742360	0.00	0.99	0.00	0.18	
Hale St. @ Squires Glen Drive	345010	4740980	0.00	1.19	0.00	0.59	
Day Care Center	345015	4741460	0.60	4.38	0.48	2.22	
Bresnahan School	345220	4742380	0.01	0.98	0.00	0.44	
Acute Care/Rehab Facility	345275	4741130	0.30	1.71	0.25	1.00	
Anna Jacques Hospital	345376	4741750	0.37	2.18	0.32	1.00	
Currier School	345464	4742360	0.08	0.82	0.01	0.41	
Knox Middle School	345590	4741100	0.16	1.24	0.11	0.75	
Newburyport High School	345725	4741550	0.26	1.26	0.13	0.76	
Elderly Housing off Low Street	346128	4741030	0.00	0.65	0.00	0.38	
Davenport School	346128	4741620	0.01	0.75	0.00	0.46	